A First Measurement of the Charged Current Cross Section at High Q^2 in Collisions of Longitudinally Polarised e^+p Scattering at HERA II

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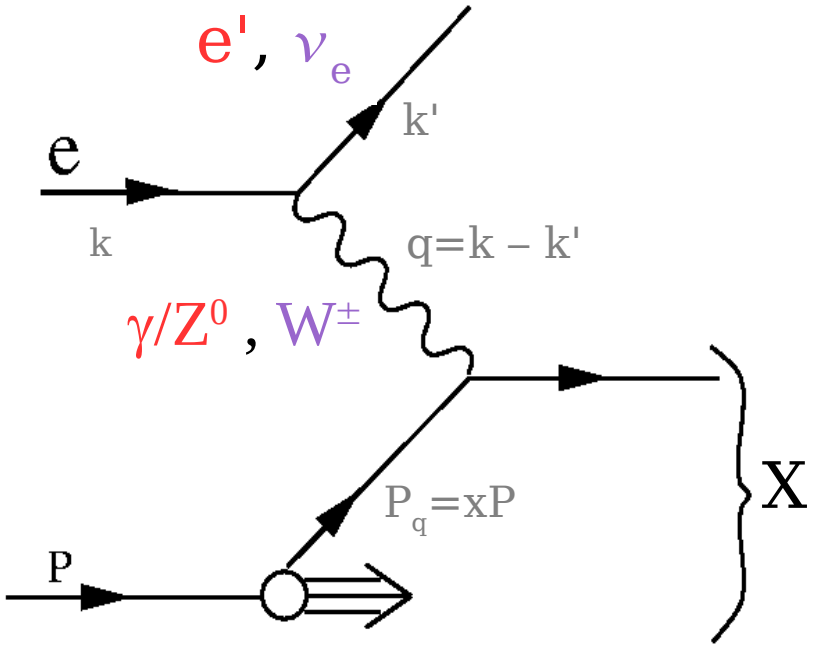
- Summary of Hera I Data
- H1 Detector at Hera II
- Polarised Charged Current Cross Section Measurement
- Future Polarised Neutral Current Measurement
- Prospects

Deep Inelastic Scattering Kinematics



Neutral, Charged Current DIS

$Q^2 = -q^2$, resolving power of probing electron

y, inelasticity of scattered lepton

x, momentum fraction of proton carried by struck quark

Cross Sections and Polarisation

$$\frac{d^2\sigma^{\pm}_{NC}}{dxdQ^2} = 2\pi\alpha^2\left[\frac{1}{Q^2}\right]^2\left[Y_+ F_2^P \mp Y_- x F_3^P - y^2 F_L\right]$$

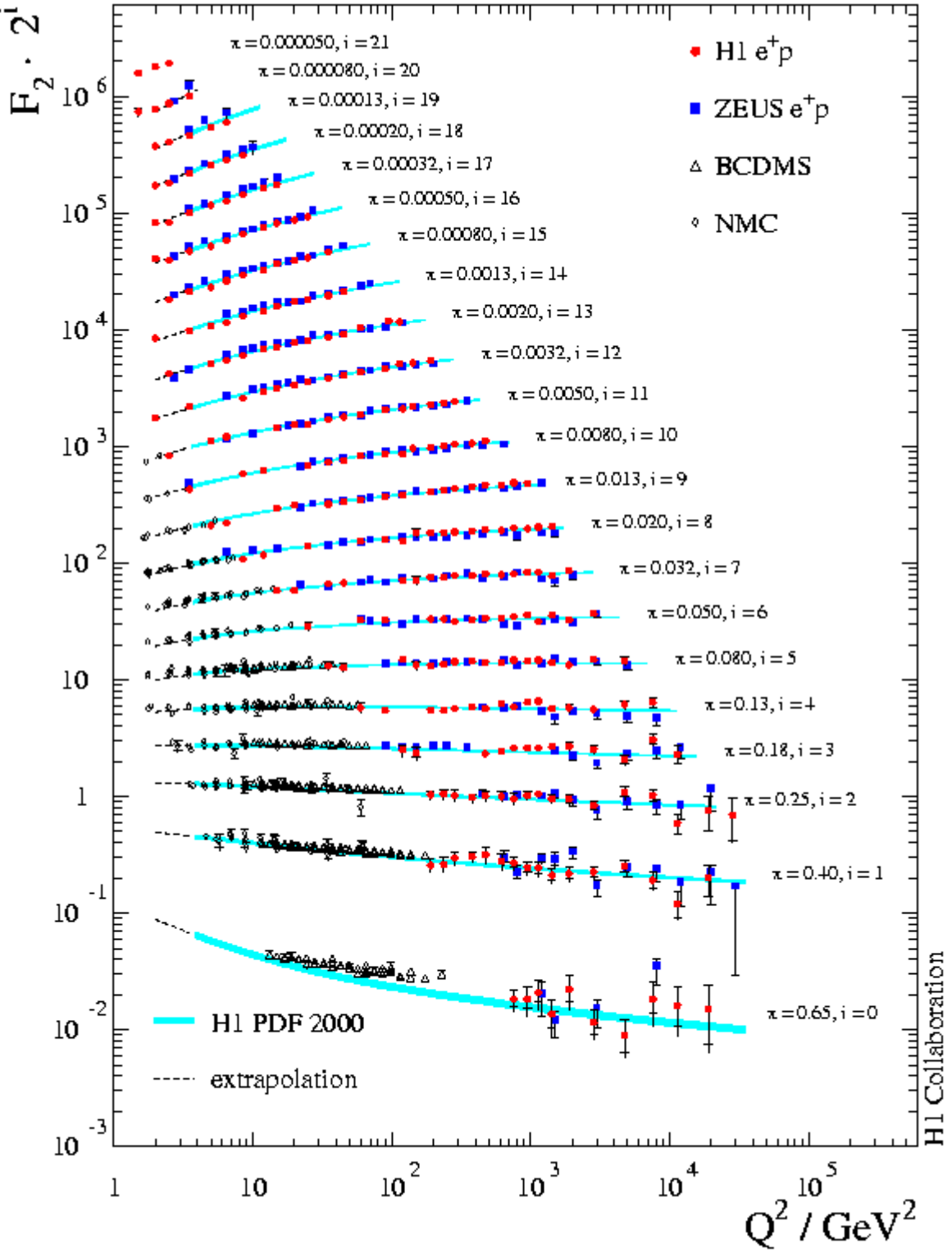
$$F_2^P = \sum_q x\left[q(x,Q^2) + \bar{q}(x,Q^2)\right]\left(A_q^0 + PA_q^P\right), \quad Y_\pm = \tfrac{1}{2}\left(1 \pm (1-y^2)\right)$$

$$A_q^0 = e_q^2 - 2e_q v_q v_e \chi_Z + \left(v_q^2 + a_q^2\right)\left(v_e^2 + a_e^2\right)\chi_Z^2$$

$$A_q^{\mathcal{P}} = 2e_q v_q a_e \chi_Z - 2\left(v_q^2 + a_q^2\right) v_e a_e \chi_Z^2$$

$$\frac{d^2\sigma^{+}_{CC}}{dxdQ^2} = \left[1+P\right]\frac{G_\mu}{\pi}\left[\frac{M_W^2}{Q^2+M_W^2}\right]^2\left[\bar{u}+\bar{c}+(1-y)^2(d+s+b)\right]$$

$$\frac{d^2\sigma^{-}_{CC}}{dxdQ^2} = \left[1-P\right]\frac{G_\mu}{\pi}\left[\frac{M_W^2}{Q^2+M_W^2}\right]^2\left[u+c+(1-y)^2(\bar{d}+\bar{s}+\bar{b})\right]$$



Structure Function F_2

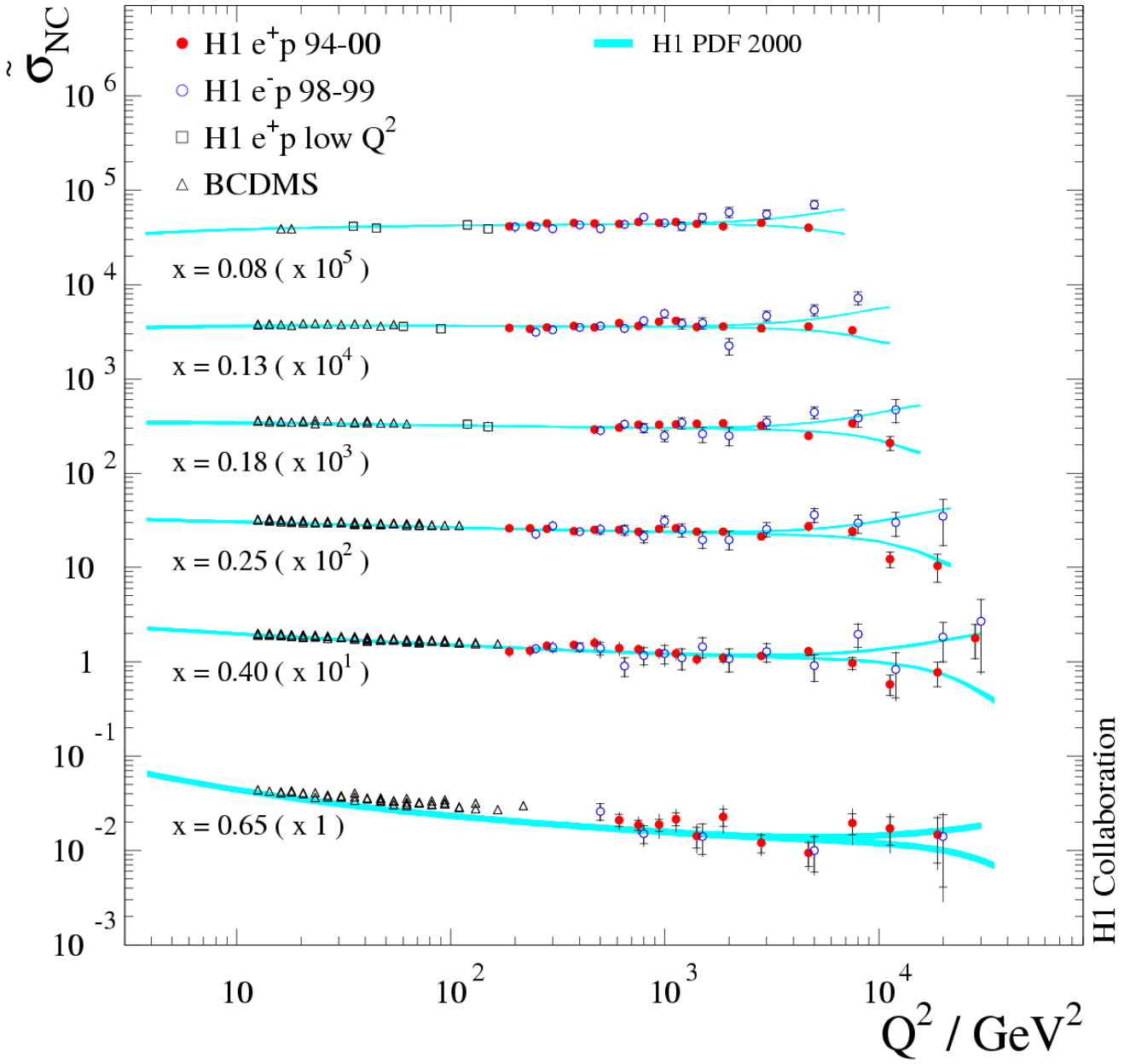
$$F_2^{em} = \sum_{quarks} e_i^2 (x q_i + x \bar{q}_i)$$

$$\frac{dF_2}{d(\ln Q^2)} \propto \alpha_s \; g(x, Q^2)$$

- F_2 measured over more than four orders of magnitude in x and Q^2
- 2-3% precision in central region
- Dominated by u at high x
- Scaling violation at low x
- Fit NLO QCD prediction of DGLAP to H1 Data
  - → Q^2 evolution well described

Reduced Cross Section

$$\tilde{\sigma}_{NC} = \frac{1}{Y_+}\frac{Q^4 x}{2\pi\alpha^2}\frac{d^2\sigma_{NC}}{dxdQ^2}$$

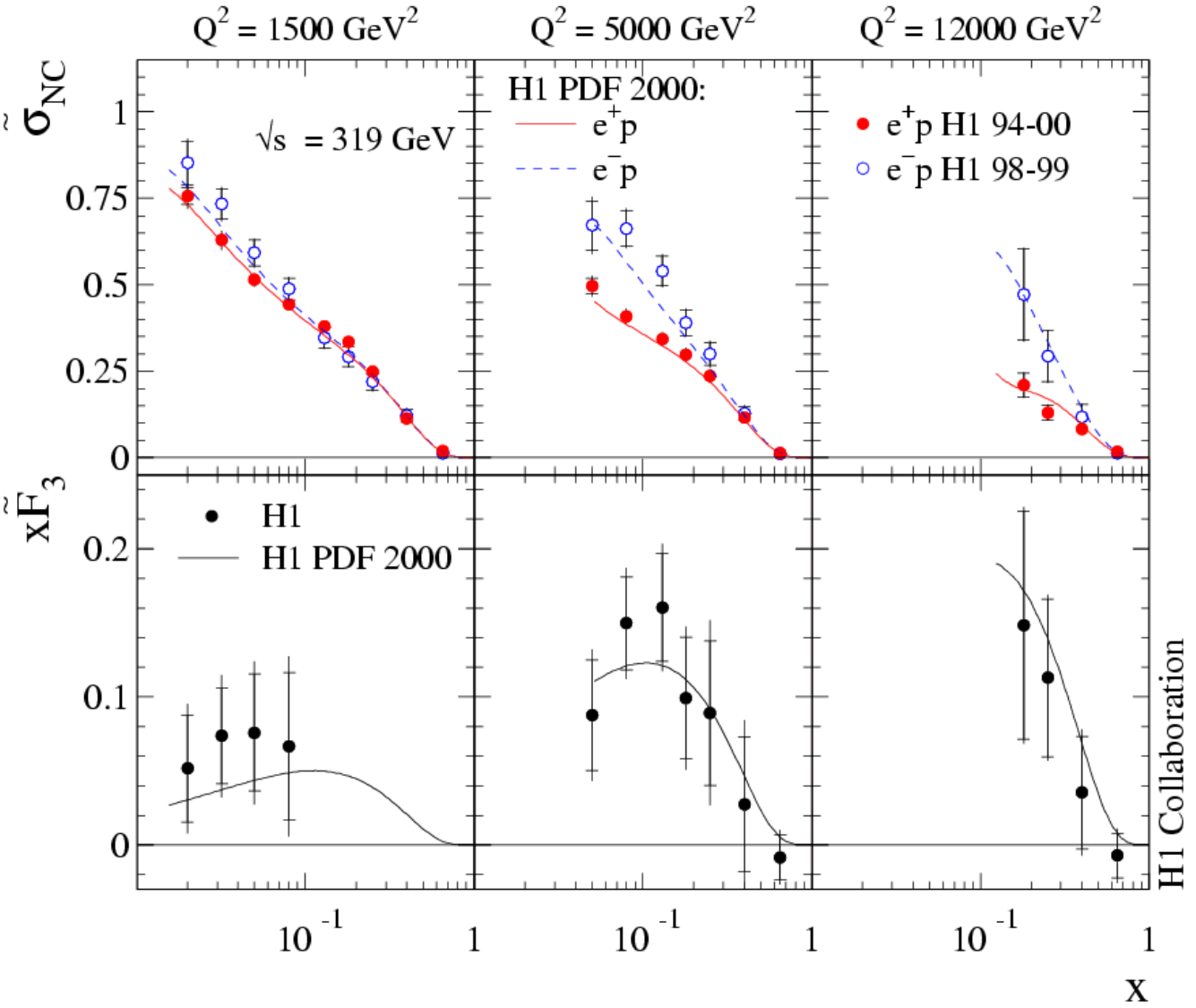


Measuring xF_3

$$xF_3 = \frac{Y_+}{2Y_-}\left(\tilde{\sigma}^-_{NC} - \tilde{\sigma}^+_{NC}\right)$$

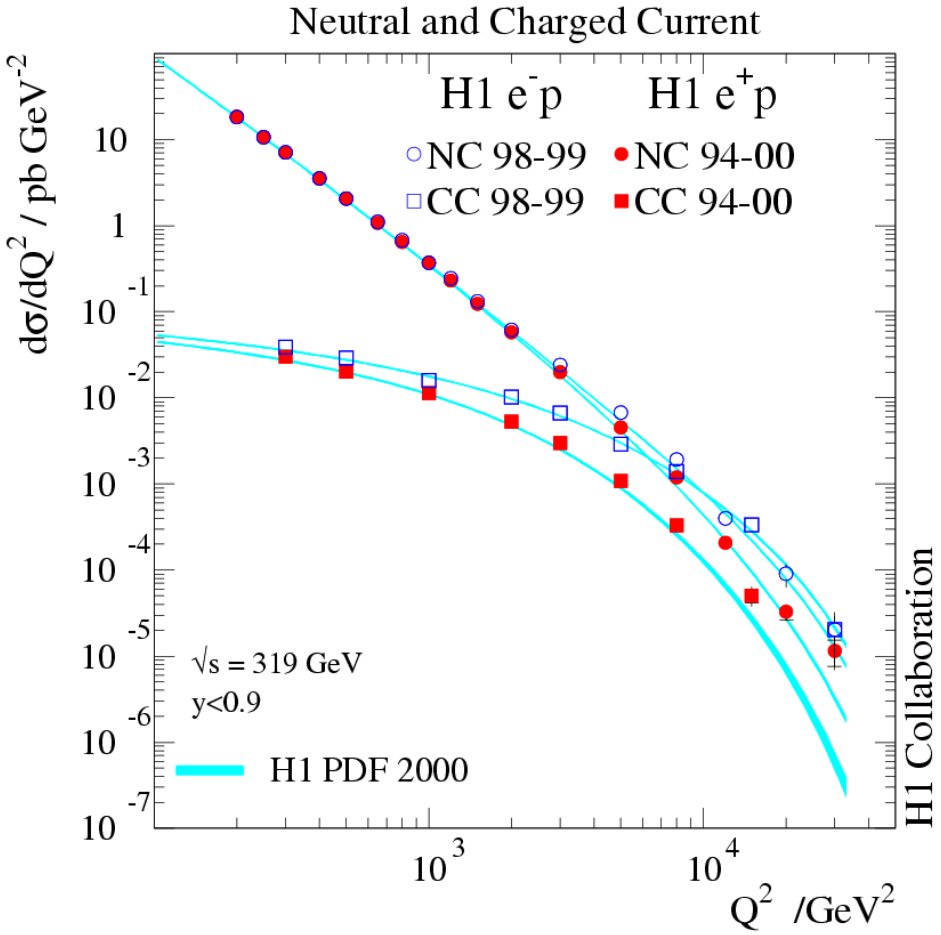
$$xF_3 = 2x \sum_{\text{quarks}} \left(q_i - \bar{q}_i\right)$$

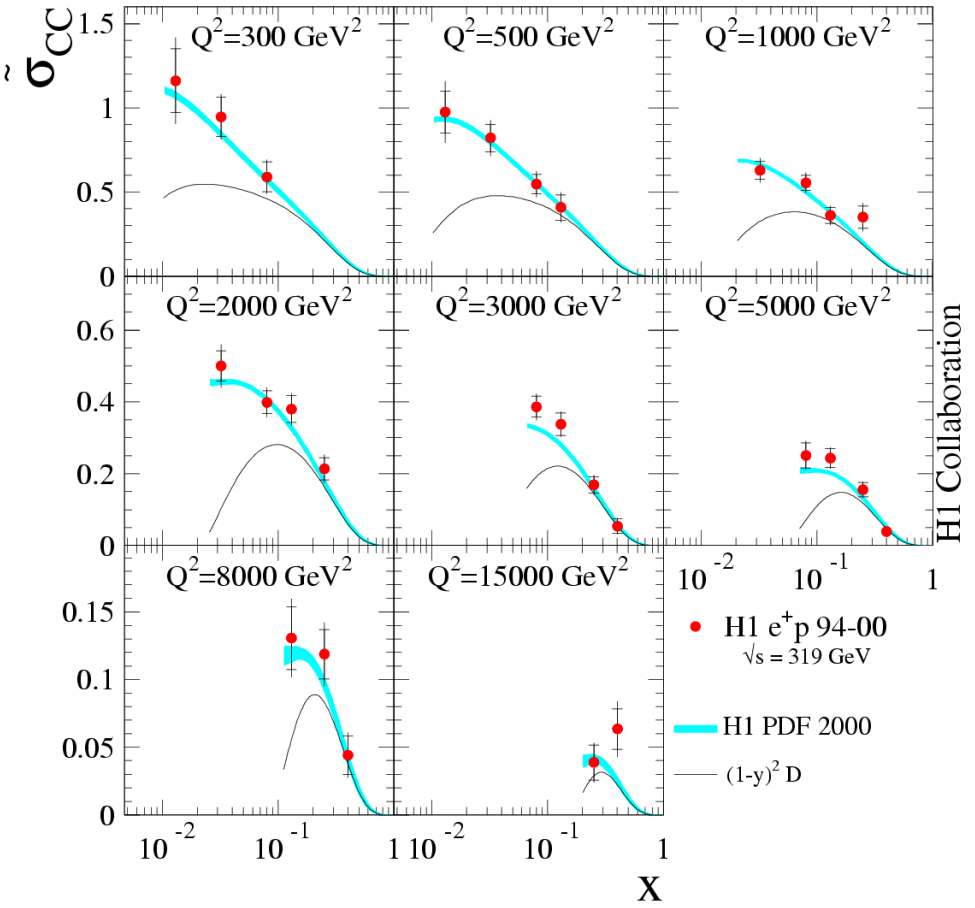
Errors limited by small e^-p luminosity (16 pb^{-1})



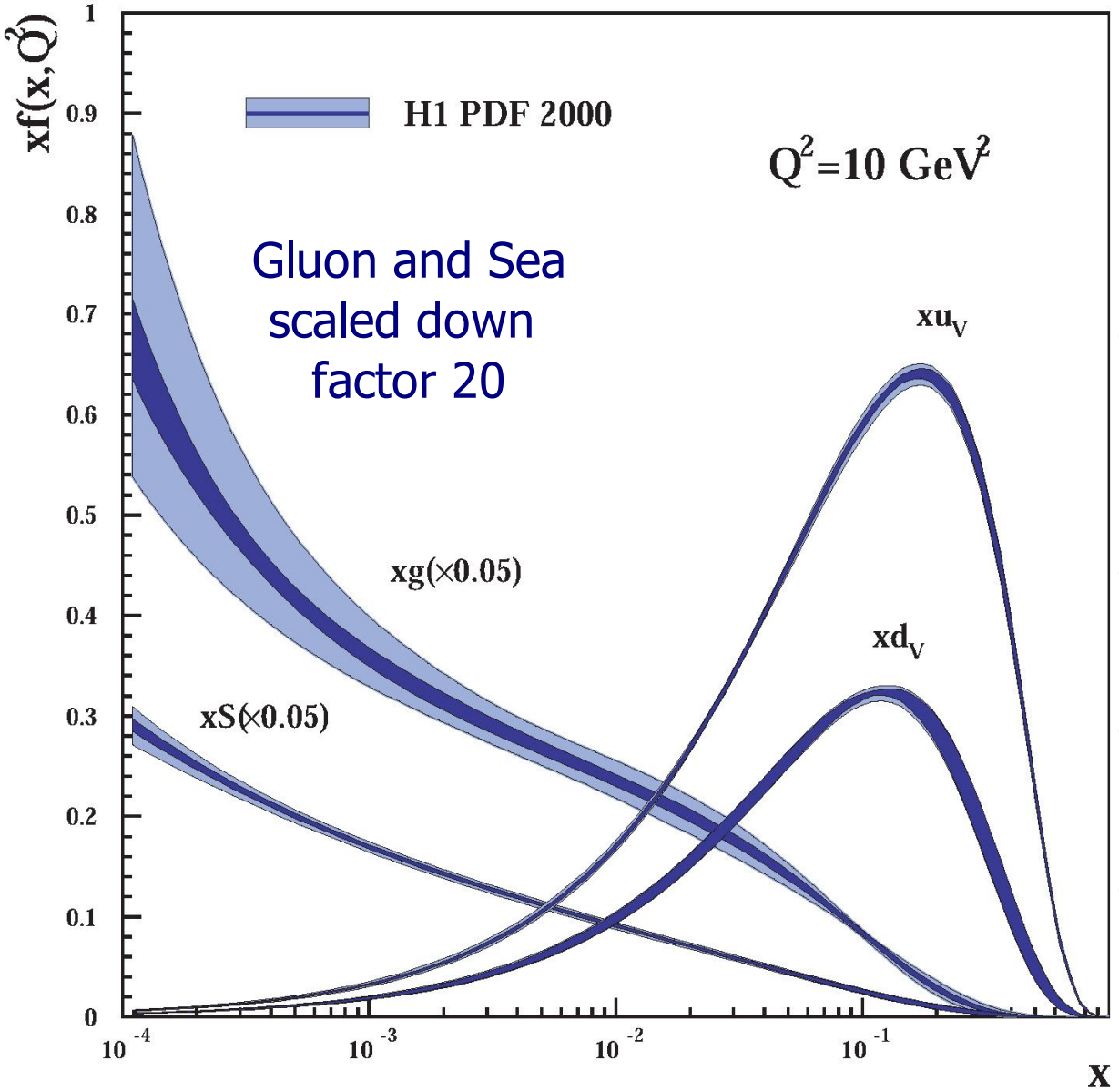
Charged Current Cross Section

- Charged current interaction suppressed by W mass at low Q^2





Quark and Gluon Density Functions



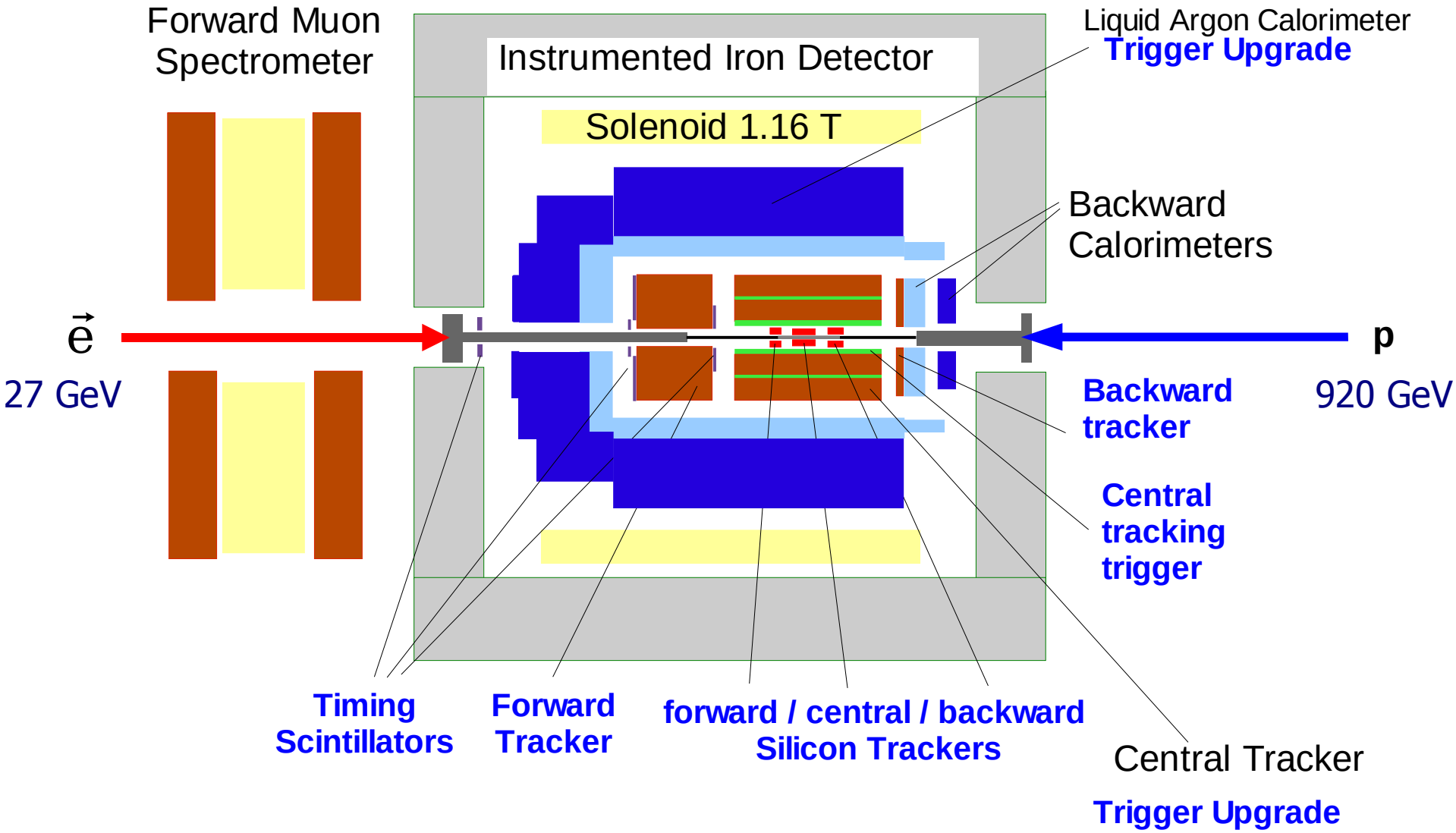
- Fit data with NLO DGLAP equations
  - → Extract parton distributions
- x dependence can only be determined from data
- Q^2 behaviour extrapolates to LHC kinematics
- See talk by Benjamin Portheault for more detail

Hera II

- H1 collected $100pb^{-1}$ of data up to end 2000
- Shutdown for upgrade in Hera ring and experimental detectors
- Five-fold increase in design luminosity achieved by
  - Focussing magnets very near Interaction Point
  - Increase in beam current
- Longitudinally polarised electron beam

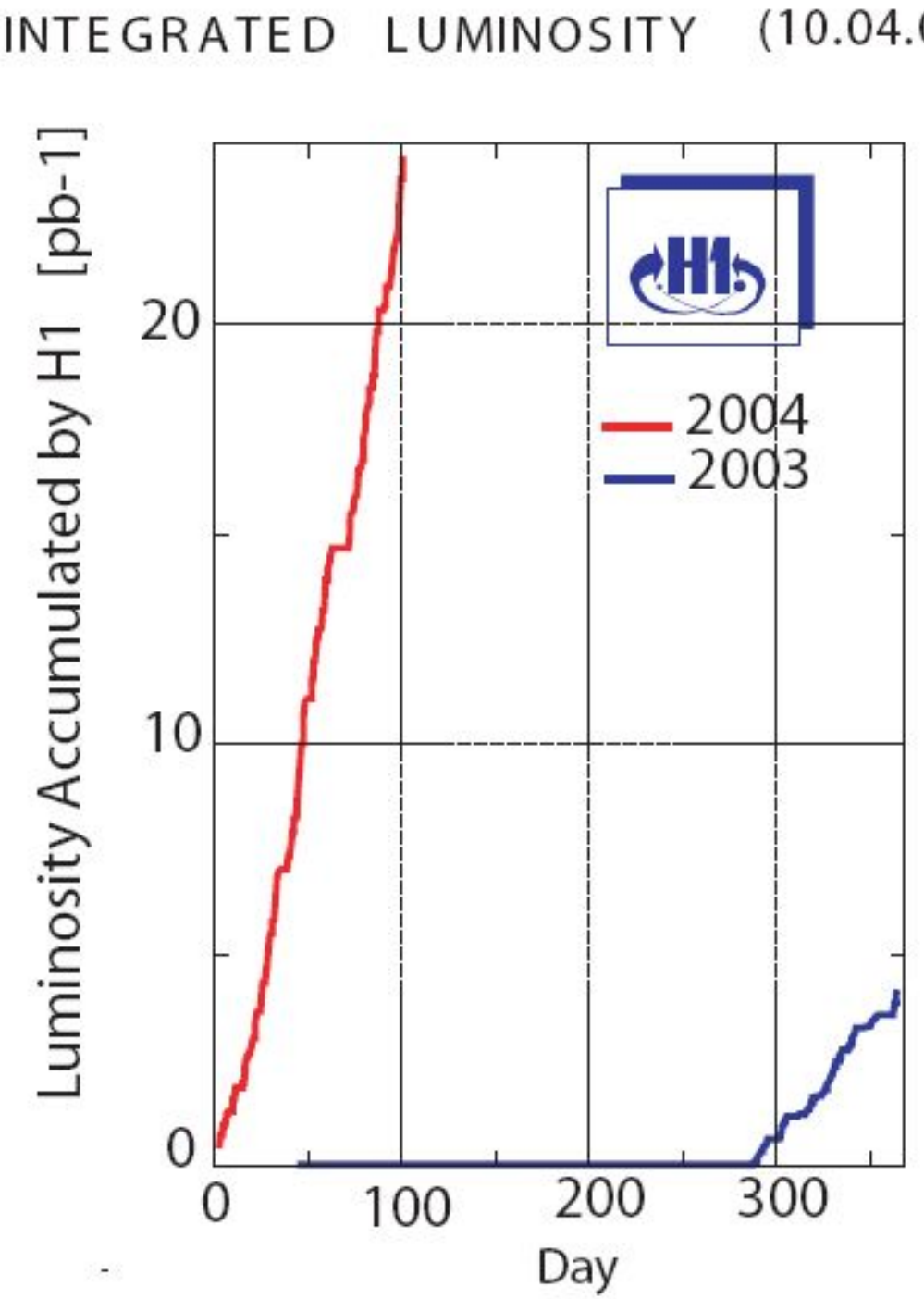
- Encountered difficult conditions upon 2002 startup
  - Studied and controlled backgrounds

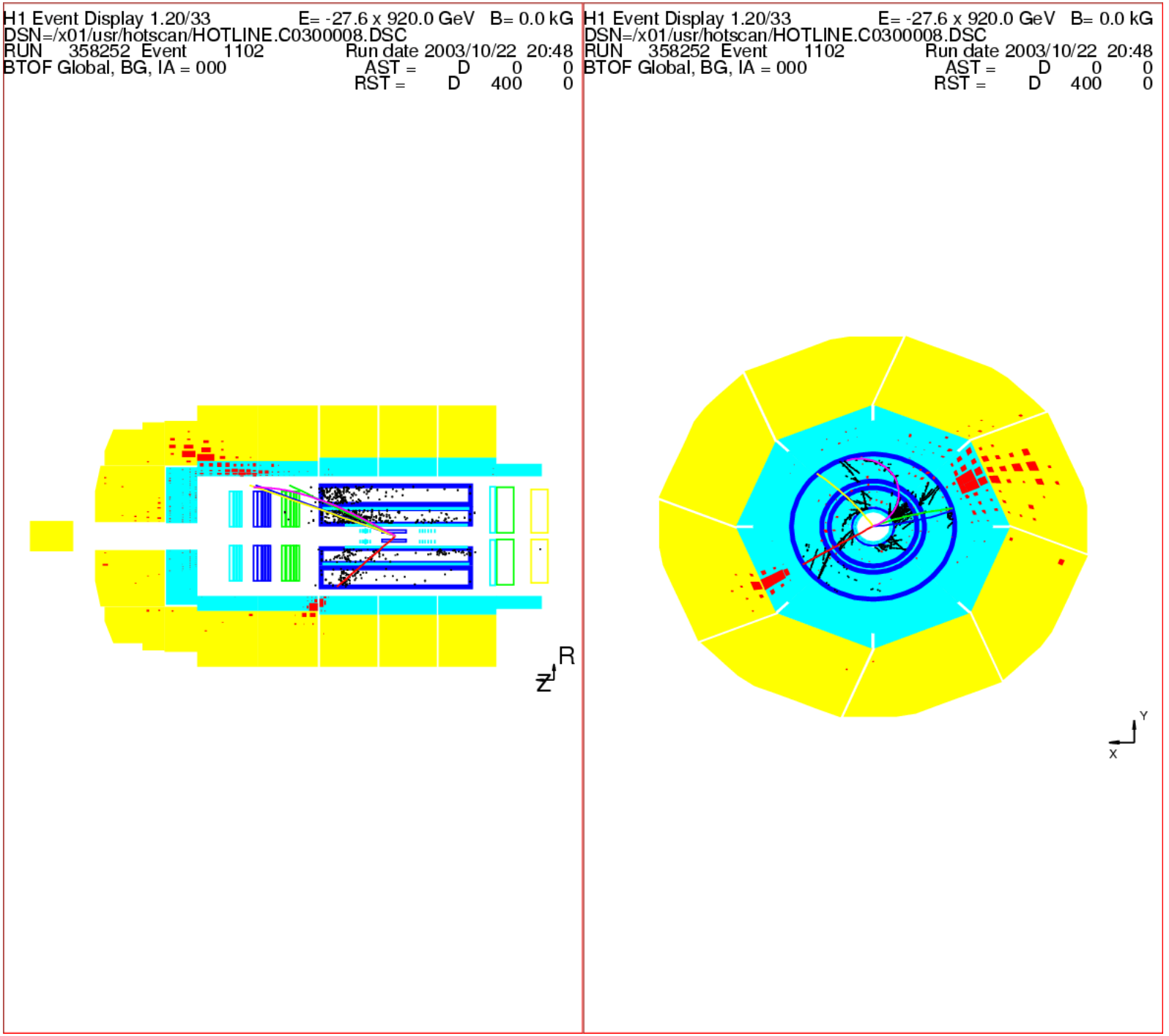
The H1 Detector at Hera II



Many **new** and **upgraded** components

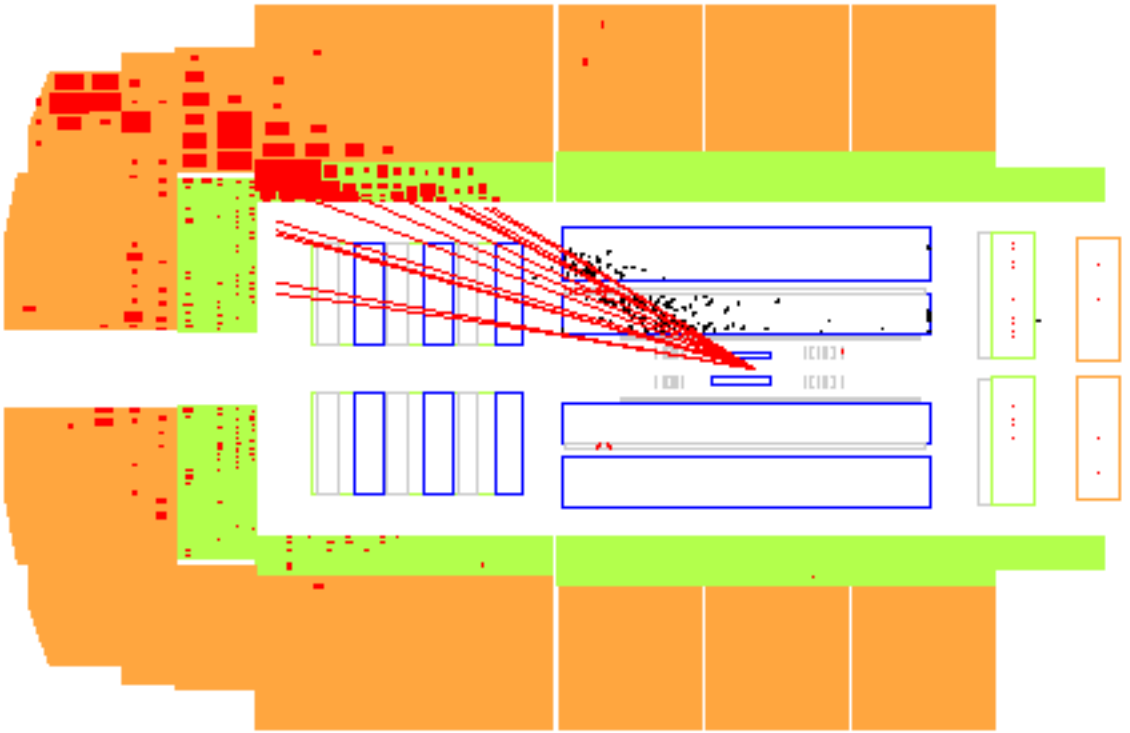
Lumi Profile

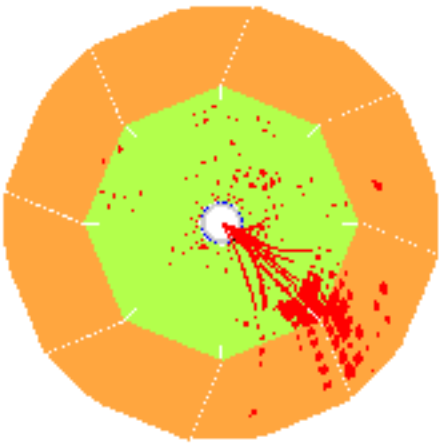


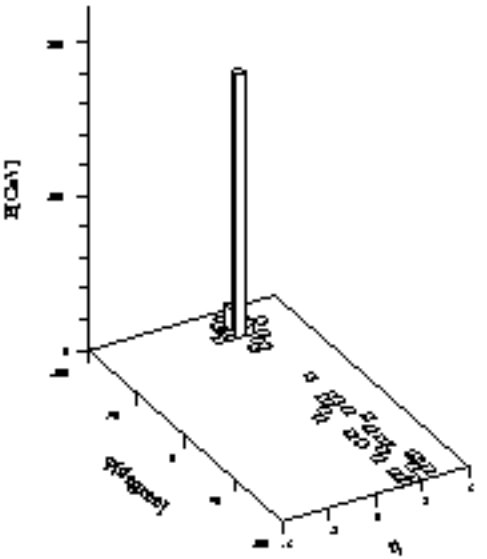

H1 Event Display 1.20/33 E= -27.6 x 920.0 GeV B= 0.0 kG
DSN=/x01/usr/hotscan/HOTLINE.C0300008.DSC
RUN 358252 Event 1102 Run date 2003/10/22 20:48
BTOF Global, BG, IA = 000 AST = D 0 0
RST = D 400 0
Z
R
H1 Event Display 1.20/33 E= -27.6 x 920.0 GeV B= 0.0 kG
DSN=/x01/usr/hotscan/HOTLINE.C0300008.DSC
RUN 358252 Event 1102 Run date 2003/10/22 20:48
BTOF Global, BG, IA = 000 AST = D 0 0
RST = D 400 0
Y
X

Run 376010 Event 7983 Class: 4 5 6 7 8 10 16 19 24 25 28 RunDate 26/03/04

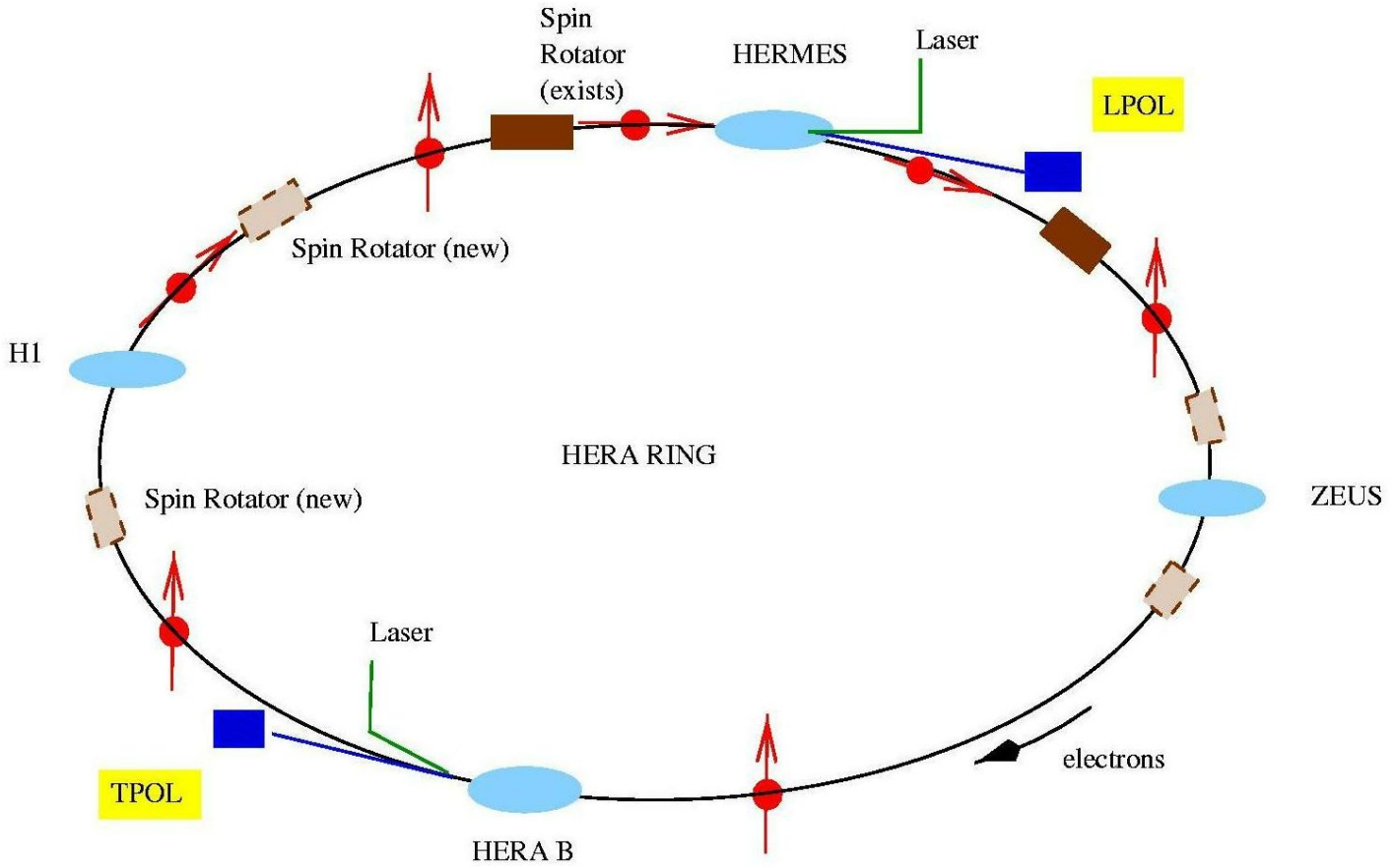
CC Q**2 = 29166 GeV**2 ; y = 0.47 ; x = 0.61





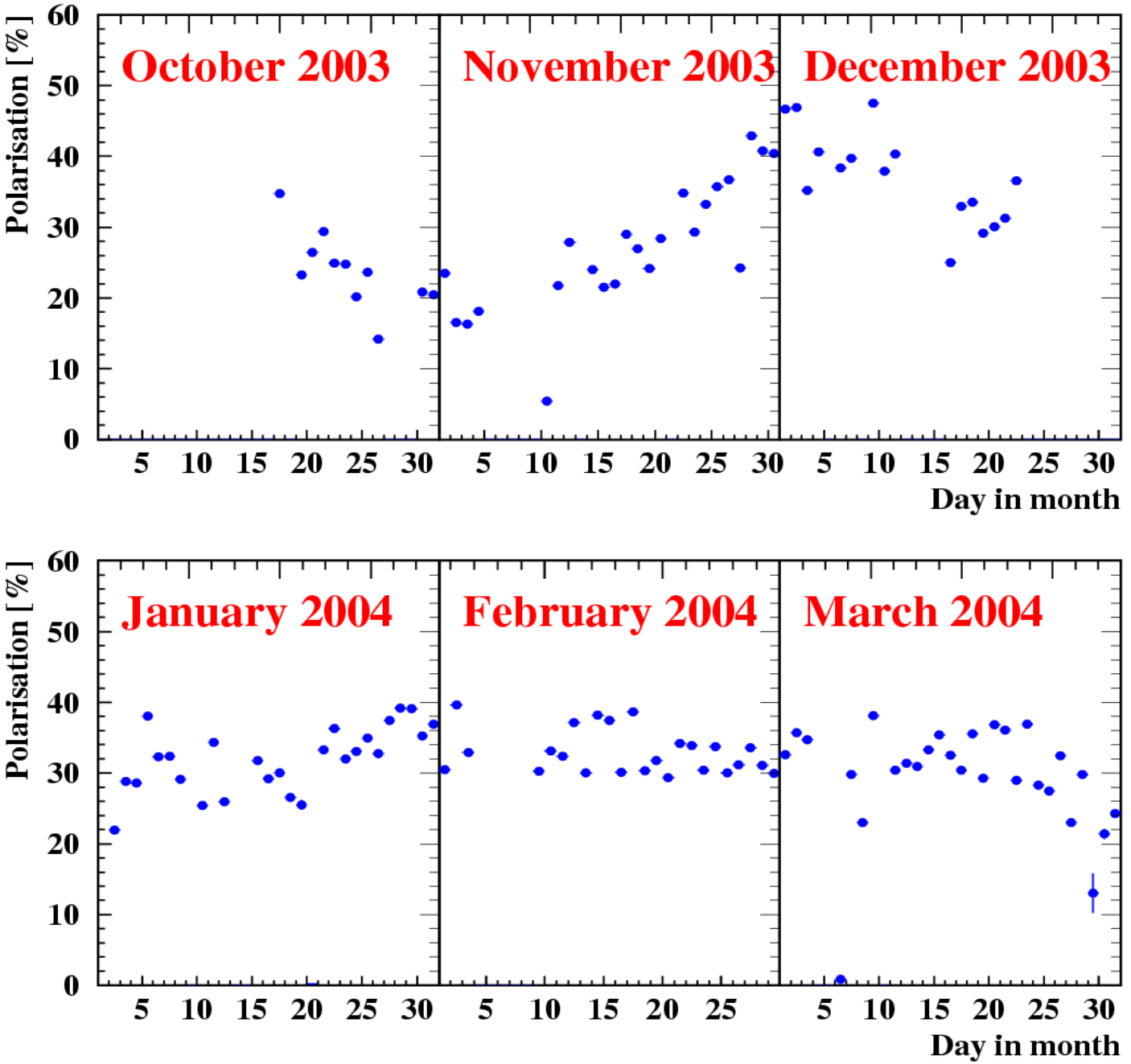


Polarisation at Hera II



- Electron beam naturally transversely polarised
- Spin Rotators at IP give longitudinal polarisation
- Polarimeters measure asymmetries in backscattered laser light

Average HERA polarisation (longitudinal polarimeter)



Data Sample

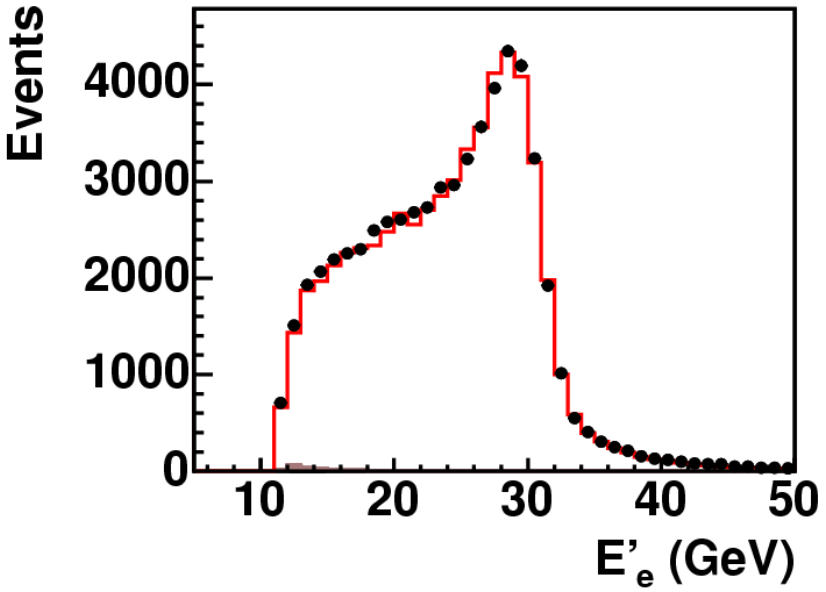
- Collected 15.3pb^{-1} of data between 15th October 2003 and 1st March 2004
- Compare with Django MC prediction
  - Reweight input Structure Functions to 2000 PDF fit
  - Simulate upgraded H1 Detector
- Pythia MC models photoproduction background

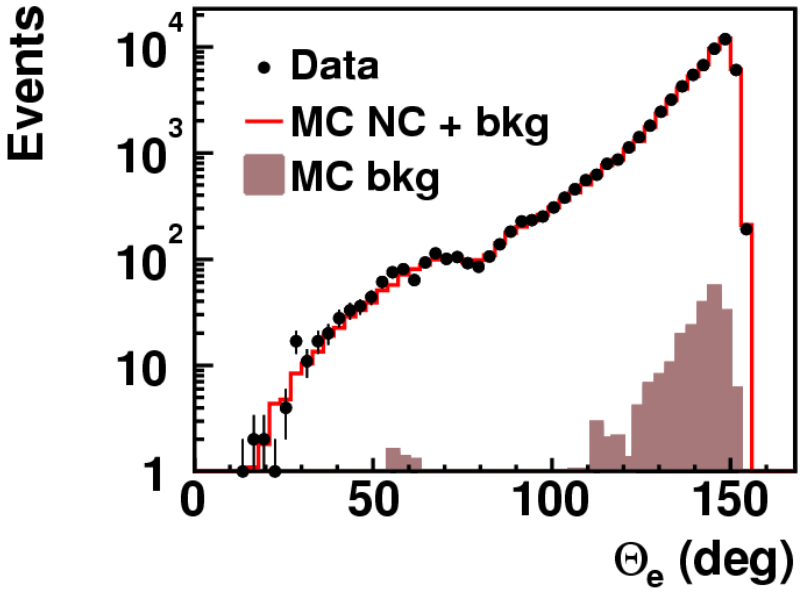
- Study detector with high statistics, clean NC Sample
- Use this understanding to measure CC cross section

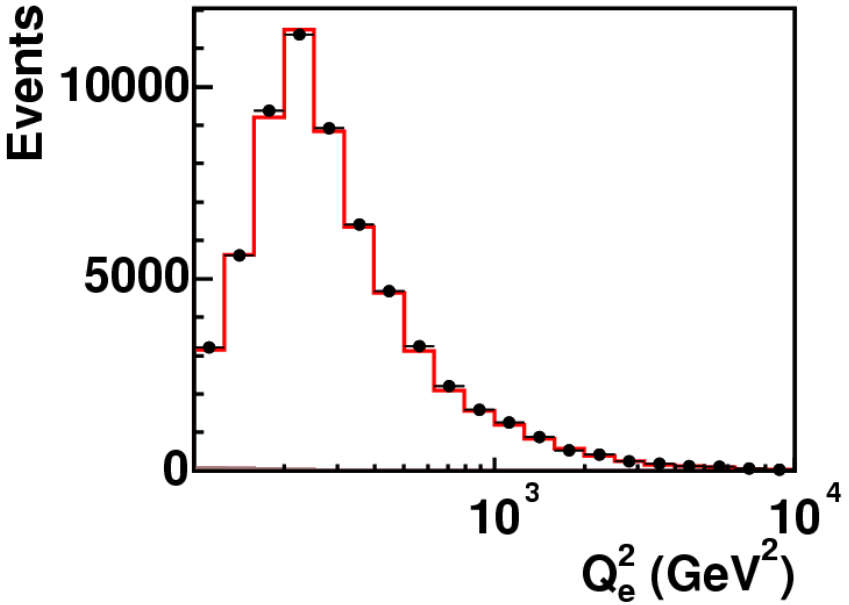
Neutral Current Event Selection

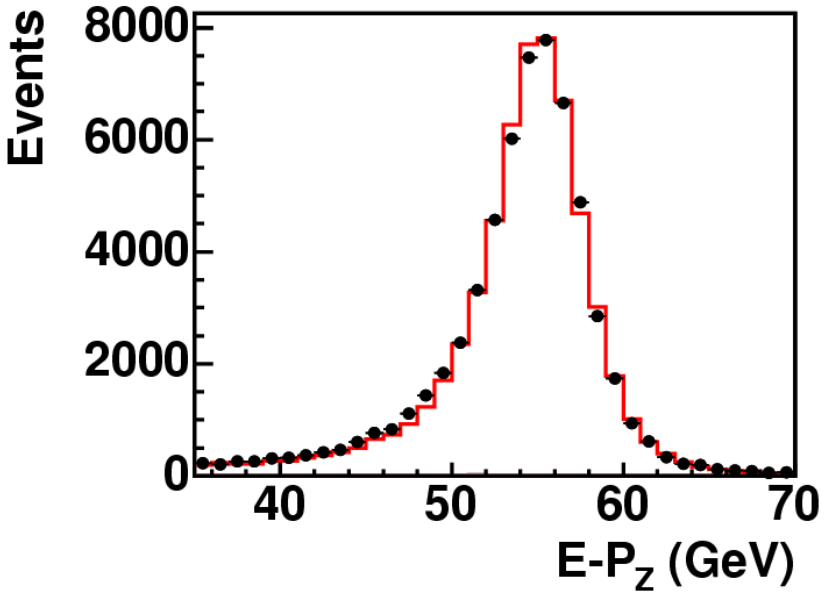
- Scattered Electron
  - QESCAT electron finder
  - High P_t electromagnetic cluster, $E_e > 11$ GeV
  - Isolated in calorimeter
  - Link to a charged track
- $E - P_z > 35$ GeV
- $y_e < 0.9$
- $Q^2 > 100\ (\text{GeV})^2$

- Energy scale calibration takes advantage of overconstrained kinematics
- Double Angle method predicts 'true' energy


Events
4000
3000
2000
1000
0
10
20
30
40
50
E'e (GeV)


Events
10^4
10^3
10^2
10
1
Data
MC NC + bkg
MC bkg
0
50
100
150
Θe (deg)

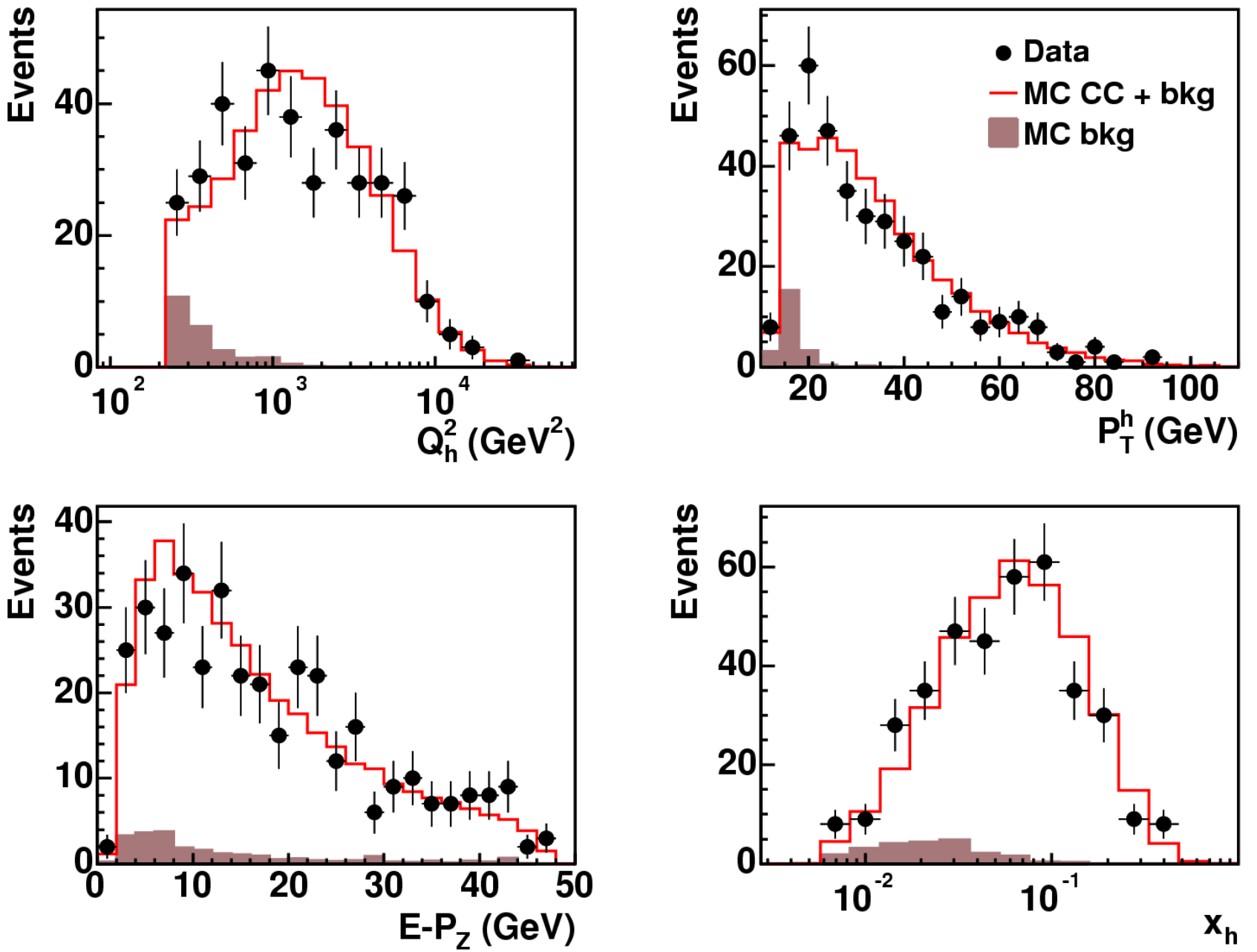

Events
10000
5000
0
10^3
10^4
Q2e (GeV2)


Events
8000
6000
4000
2000
0
40
50
60
70
E-PZ (GeV)

Charged Current Measurement

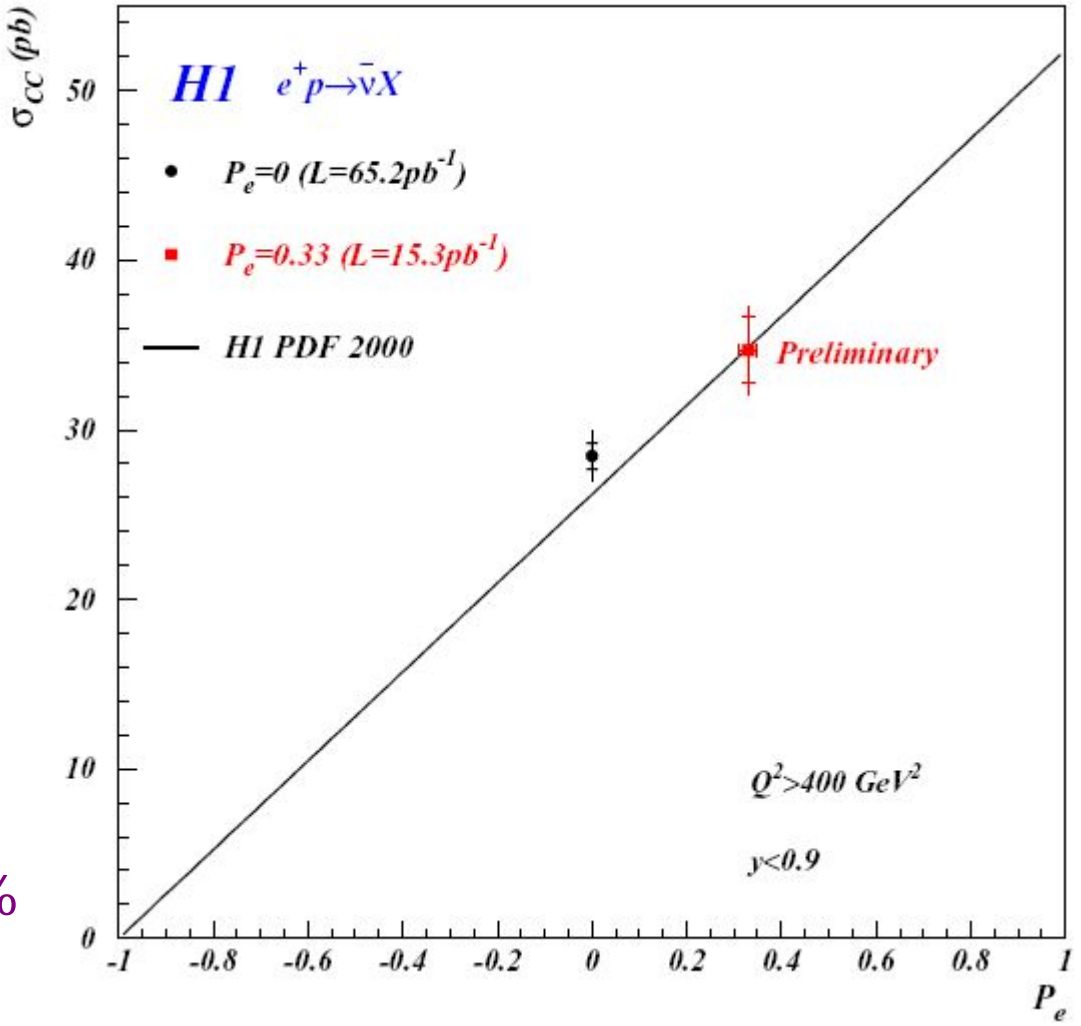
- Reject events with Scattered Electron candidate
- Require high missing P_t, attributed to neutrino
- Energy balance in calorimeter, $V_{ap} / V_p < 0.2$

- $0.03 < y_h < 0.85$
- Measure $Q^2 > 400$ (GeV)^2


Events
40
20
0
10^2
10^3
10^4
Q_h^2 (GeV^2)
Events
60
40
20
0
Data
MC CC + bkg
MC bkg
20
40
60
80
100
P_T^h (GeV)
Events
40
30
20
10
0
0
10
20
30
40
50
E-P_Z (GeV)
Events
60
40
20
0
10^{-2}
10^{-1}
x_h

Charged Current σ_{Tot}

- Polarisation expected to have a linear (1+P) influence on CC cross section
- First measurement made on lepton helicity dependence of $ep \rightarrow \upsilon X$ with ≈ 33% Polarisation
- Consistent with SM
- 2.3σ polarisation effect

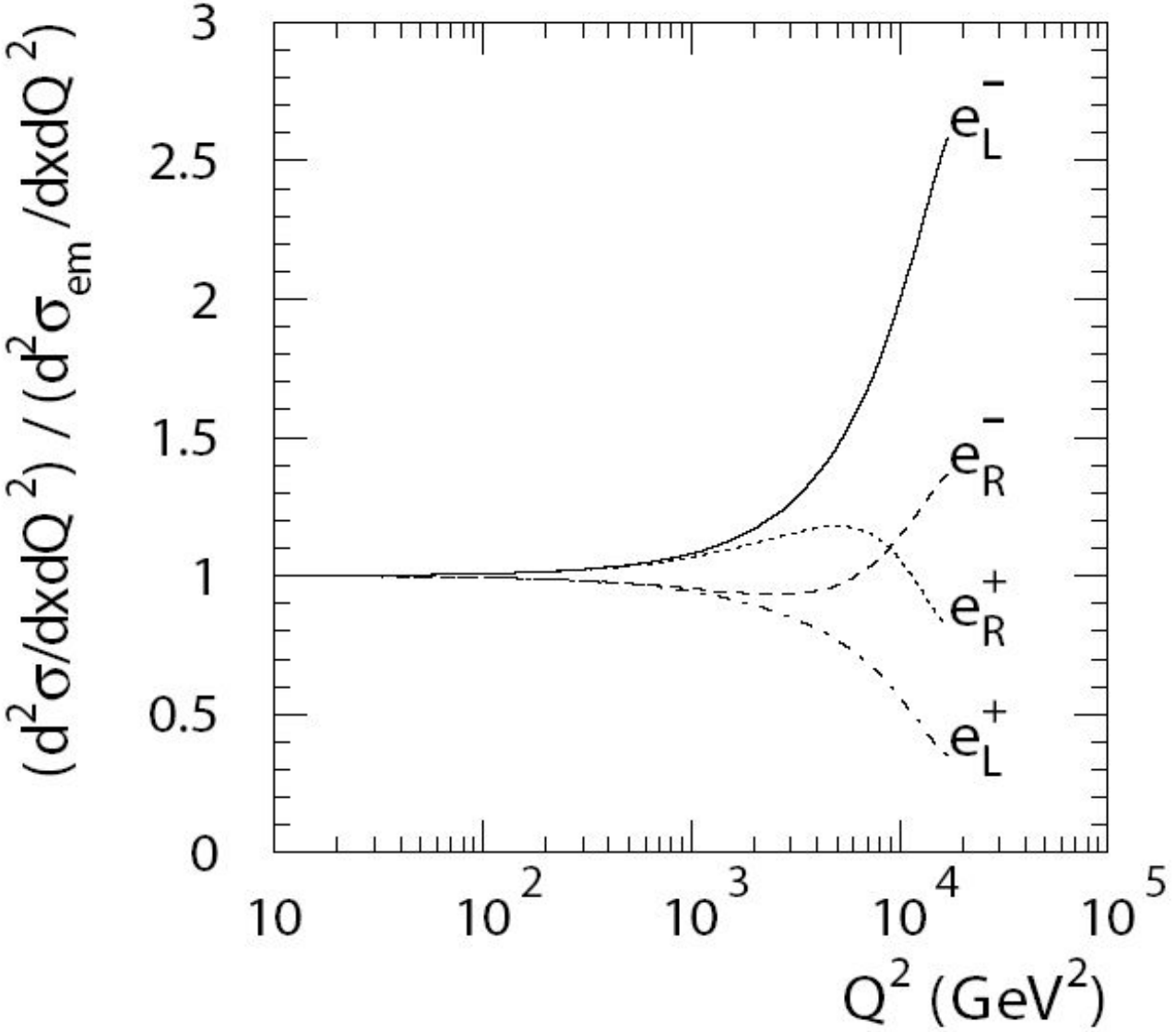


σ^{P}_{CC} = 34.67 pb ± 5.6% (stat.) ± 4.8% (syst.)

P=(33 ± 2) %

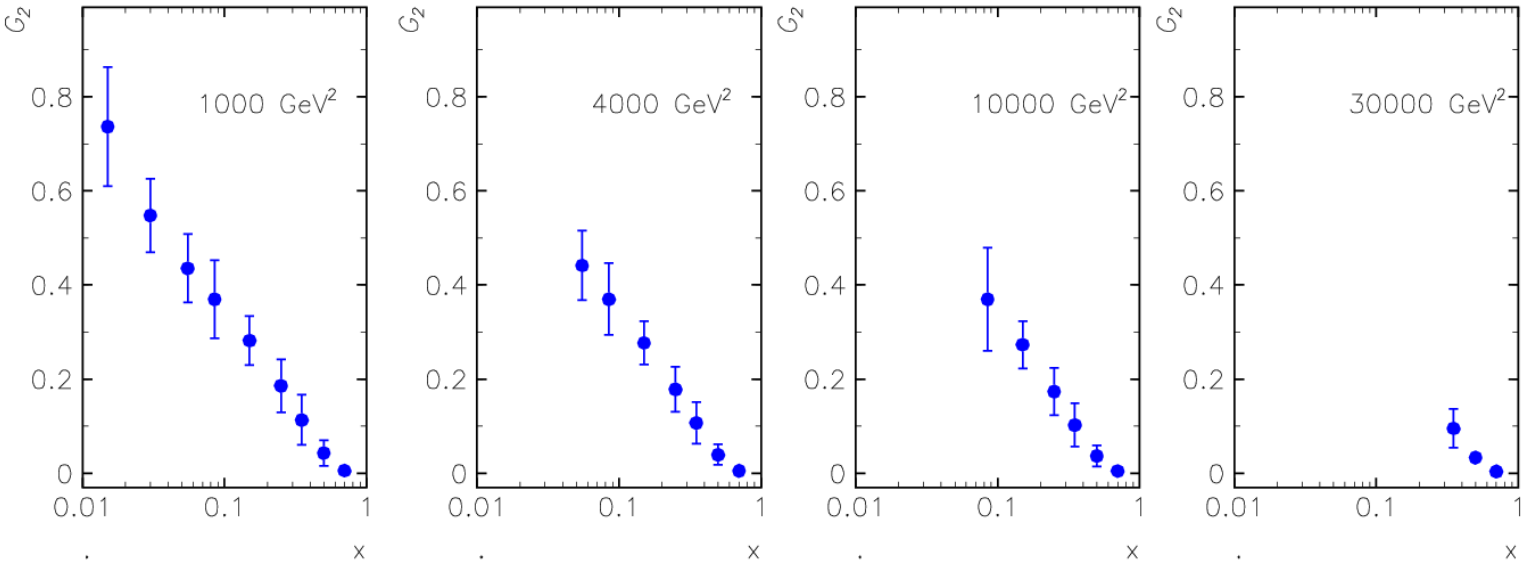
σ^{0}_{CC} = 28.44 pb ± 2.7% ± 4.3%

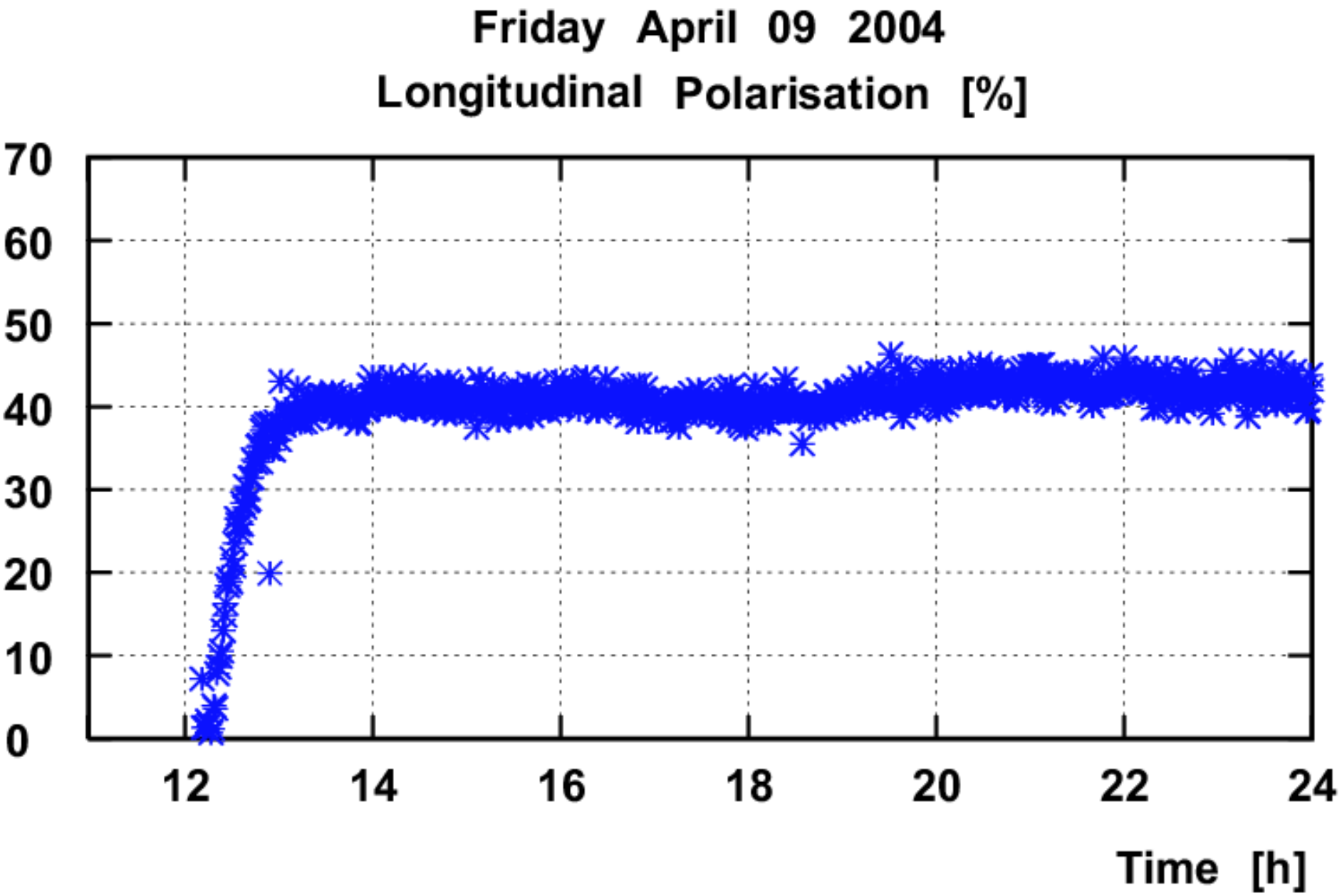
Polarised Neutral Currents



Polarised Neutral Currents

$$\text{Asym} = \frac{\sigma_{NC}(+P) - \sigma_{NC}(-P)}{\sigma_{NC}(+P) + \sigma_{NC}(-P)} \approx -\kappa_Z a_e \frac{G_2}{F_2} \rightarrow P \frac{1 + d/u}{4 + d/u}$$




Friday April 09 2004
Longitudinal Polarisation [%]
70
60
50
40
30
20
10
0
12
14
16
18
20
22
24
Time [h]

Summary

- First new measurement of helicity dependence of $ep \rightarrow \upsilon X$ interaction
- A Polarised Neutral Current measurement offers a new handle to extract precise physics
- A Polarised Charged Current measurement is a simple and powerful test of the standard model
- Hera has delivered the first set of right-polarised positron data and is now running with the opposite helicity.
- First step towards a demonstration of polarisation dependence of charged and neutral current cross sections